

E1 applying an electric current and a magnetic field to the simultaneously to the metallic material during a solidification process at temperatures lower than the liquidus of the molten metallic material to crush into small pieces solid crystals of the metallic material generated during the solidification process and to shift the small pieces to a periphery of the metallic material in the closed container; and

yielding a refined microstructure of the metallic material concentrated in the end portion of the metallic material in the closed container.

REMARKS

Favorable reconsideration of the present application in light of the above amendment and in light of the following discussion is respectfully requested.

Claims 15, 18 and 19 are presently active in this case, Claim 15 having been amended by the present amendment.

In the outstanding Office Action, Claims 15 and 18 were rejected under 35 U.S.C. §102(b) as being anticipated by Vives ("Effects of Forced Electromagnetic Vibrations ..."); Claim 19 was rejected under 35 U.S.C. §103 (a) as being unpatentable over Vives; and Claims 15, 18 and 19 were rejected under 35 U.S.C. §103 (a) as being unpatentable over Radjai et al. ("Effects of Electromagnetic ...") in view of Vives.

The amendment to Claim 15 is not believed to raise an issue of new matter because the phenomenon described in Applicants' specification takes place in a closed vessel as described in, for example, page 14, lines 1-12, of the specification.

Briefly, Claim 15 according to the present invention is directed to a method for producing a refined microstructure of a metallic material and shifting the refined material to a

periphery of a closed container to yield the refined material concentrated in the end portion of the material, including subjecting the molten metallic material to a solidification process at temperatures lower than a liquidus of the molten metallic material, applying an electric current and a magnetic field simultaneously to the metallic material during a solidification process at temperatures lower than the liquidus of the molten metallic material to crush into small pieces solid crystals of the metallic material generated during the solidification process and to shift them to the periphery of the metallic material in the closed container, and yielding a refined microstructure of the metallic material concentrated in the end portion of the material in the closed container.

An advantage of the subject matter recited in Claim 15 over the background art is that a refined microstructure of a metallic material is produced and shifted to a periphery of a closed container and thereby the refined material concentrated in the end portion of the material in the closed container is yielded.

Vives discloses a grain refinement method for aluminum alloy by applying an electric current and a magnetic field simultaneously to the molten aluminum alloy during a solidification process at temperature lower than a liquidus of the alloy. However, Vives does not mention shifting a refined material to a periphery of a closed container to yield the refined material concentrated in an end portion of the metallic material. At temperatures lower than the liquidus primary silicon starts to grow in size by absorbing dissolved silicon from the melt. Oscillatory motion of these particles caused by vibrations of the melt and the fact that they have an active surface going under solidification results in sticking of the particles to their neighboring ones and a local agglomeration (See Fig. 1 submitted herewith). These agglomerates, having an electrical conductivity much lower than the melt and therefore not being directly affected by the pinch or vibrating forces, move toward the

surrounding surfaces against the direction of the pulsating pinch force confining the melt as a reaction (See Fig. 2 submitted herewith). The pinch force is developed by the interaction of the alternating current passed through the melt and the magnetic force that is induced by the electric current. As is schematically shown, the direction of the pinch force is inward regardless of the direction of the current. This phenomenon could not be confirmed in experiments where only an alternating electric current of the same density was imposed. This shows that the above effect is due to a combination of both vibrating and pinch forces rather than the latter alone. Moreover, the fact that it is observed only after the start of solidification implies that the agglomeration of particles to specific size is a necessary condition for this phenomenon to occur.

This phenomenon could not take place in Vive's research due to the following facts:

1. The vessel is not closed; and
2. The primary phase is highly conductive aluminum rich, rather than the almost semi-conductor silicon.

In the subject matter recited in Claim 15, a container is closed, and thereby, the phenomenon discussed above takes place. On the other hand, if a vessel which is not closed is used, the phenomenon cannot take place. Shifting occurs when the closed container is used; however, shifting cannot occur when an open vessel is used. In Vives, a container which is closed is not used or disclosed, and therefore, the Vives process cannot produce the same result as that of Applicants.

The Office Action further asserts that "Radjai et al. substantially show the invention as claimed except they do not disclose crushing solid crystals into small pieces during a solidification process at temperatures lower than the liquidus." As commented in the Office Action, Radjai et al. do not disclose crushing solid crystals into small pieces during a

solidification process at temperatures lower than the liquidus. Further, Radjai et al. do not disclose shifting the refined material to a periphery of a container to yield the refined material concentrated in the end portion of the material in the container by a simultaneous application of an electric current and a magnetic field to the metallic material at temperatures lower than liquidus thereof. Vives discloses effects of forced electromagnetic vibrations during the solidification of aluminum alloys. However, Vives does not disclose shifting the refined material to a periphery of a closed container to yield the refined material concentrated in the end portion of the material in the closed container by a simultaneous application of an electric current and a magnetic field to the metallic material at temperatures lower than liquidus thereof.

Radjai et al. disclose “[s]uspended silicon particles multiplied in number with a reduction in size by vibrations at temperatures higher than the liquidus and agglomerated and repelled to the outer surface after the start of solidification.” That is, Radjai et al. disclose that suspended silicon particles agglomerated and repelled to the outer surface.

On the bases discussed above, Applicants respectfully submit that substantial differences exist between Radjai et al. and the subject matter recited in Claim 15.

In addition, according to Radjai et al., the suspended silicon particles are used and the particles are multiplied in number with a reduction in size by vibrations at temperatures higher than the liquidus. On the contrary, in the subject matter recited in Claim 15, solid crystals of the metallic material generated during the solidification process are used and the crystals are crushed into small pieces by applying an electric current and a magnetic field simultaneously to the metallic material during a solidification process at temperatures lower than the liquidus to shift them to a periphery of the metallic material in a closed container. For the foregoing reasons, it is respectfully submitted that it would not have been obvious to

crush solid crystals of the metallic material generated during the solidification process by applying an electric current and a magnetic field simultaneously to the metallic material during a solidification process at temperatures lower than the liquidus to shift them to the periphery of the metallic material in the closed container and to yield them concentrated in the end portion of the material in the closed container and that Radjai et al. do not disclose what Applicants have discovered and do not make the presently claimed method obvious, even in view of the teachings of Vives.

In view of the presently submitted amendments and discussions presented above, the subject matter recited in Claim 15 is believed to define over Radjai et al. and Vives, and thus the present application is believed to be in condition for allowance. Therefore, an early action favorable to that effect is earnestly solicited.

Finally, the attention of the Patent Office is directed to the change of address of Applicants' representative, effective January 6, 2003:

Oblon, Spivak, McClelland, Maier & Neustadt, P.C.

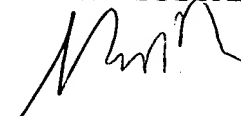
1940 Duke Street

Alexandria, VA 22314.

Please direct all future communications to this new address.

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,
MAIER & NEUSTADT, P.C.



Gregory J. Maier
Registration No. 25,599
Robert T. Pous
Registration No. 29,099
Attorneys of Record



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Tel: (703) 413-3000

Fax: (703) 413-2220

GJM/RTP/AY:fm

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